Providing Next-Generation EV Battery Protection Without Compromise

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Sales of electric vehicles, or EVs, are on the rise. The U.S. Department of Transportation has reported consecutive growth over a five-year period leading up to 2020, as well as record highs in March 2021 — both in terms of light-duty vehicle market share and overall monthly sales volume. The International Energy Agency has also reported significant leaps in global electric car sales throughout the past decade; China, the largest market, is also leading the world in the electrification of urban buses. Full battery electric vehicles (BEVs), with higher pack density, are also becoming a larger portion of the total EVs sold.

Among the most significant drivers of these trends is the continued evolution of the battery pack design, and the protective material solutions being developed to extend its lifespan and maximize its performance. Even more critical to battery pack protection is the need to ensure safety, specifically in the event of a thermal runaway. Thermal runaway occurs when a thermal event propagates from cell to cell, creating a cascade — and ultimately, an explosion.

Despite the obvious importance of this type of protection, there have been shortcomings in the material solutions that have historically been available in the market. However, our new product line addresses those shortcomings head-on.

Battery Pack Protection Basics

The viability of EVs as a transportation option is dependent upon the rechargeability of their battery packs. Generally, those packs are comprised of modules, inside of which are clusters of individual battery cells. The cells undergo internal chemistry changes during charge/discharge cycles causing them to expand and contract in a way that is sometimes thought of as “breathing.”

This process introduces a vulnerability to the system, impacting the stability of electrical and thermal connections. Typically, this is addressed by dielectric compression pads, deployed between cells to maintain pressure and keep connections secure while still allowing the battery to breathe. These pads also provide thermal insulation between cells, thereby directing heat from a cell toward a heat sink and providing basic thermal management.

Internal defects or external conditions can also lead to premature aging of the cell components. Mechanical abuse may come in the form of a vehicle crash, or penetration directly into the battery, which may lead to a short circuit and overheating of a cell. Overcharging or external heat conditions could also lead to increased temperature of the battery. Considering these cells are densely packed together, it is possible for a thermal event to then propagate to adjacent cells or modules.

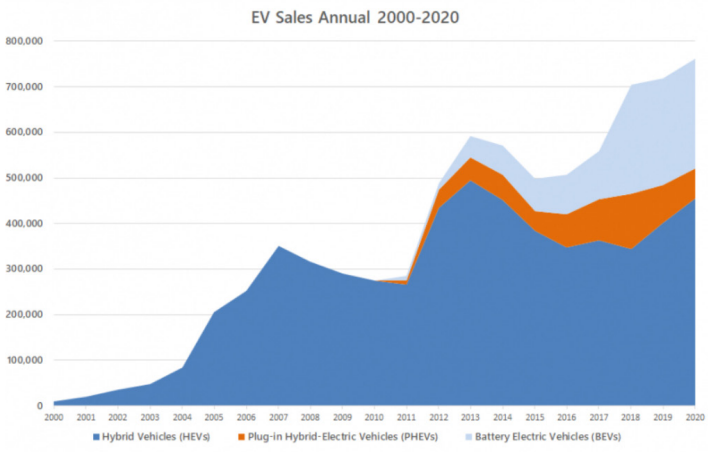

Figure 1. The U.S. Department of Transportation has reported consecutive growth in EV sales over a five-year period leading up to 2020.

Source: Bureau of Transportation Statistics.

Individual materials have been developed to mitigate the potential for thermal propagation, but — as with any non-cell material — incorporating them into EV battery construction diminishes the energy density of the pack. As a result, designing an EV battery for extreme conditions tends to force a choice: opting for maximum energy density and performance or ensuring safety. This is the sort of trade-off no manufacturer should ever have to face.

Combination Approach

We have devised a solution to this dilemma by combining the lifespan-enhancing utility of a compressible pad and the lifesaving power of thermal runaway protection into a single product, offering minimal impact on energy density while providing greater protection on multiple fronts.

The **Norseal**® TRP Series is designed to keep battery cells under a defined range of protection, capable of serving as compression pads for pouch-cell packs or cushioning pads for prismatic hard-shell packs. In the place of vulnerable elastomer materials are dielectric foams engineered with a predictable compression force deflection (CFD). This allows them to deliver consistent return energy over a wide range of compression amounts and temperatures throughout battery pack life. The foam's low compression set value also translates to the ability to resist permanent deformation under compressive loads.

At the same time, the foam serves not only as a temperature-resistant thermal insulator, but as a thermal runaway protector as well — hence the "TRP" referenced in the name of the product line.

The foam is engineered to be heat-absorbent and flame-resistant, protecting adjacent cells from going exothermic and helping to mitigate the propagation of a thermal event from one cell to another. It is also electrically insulating, preventing arcing within modules.

Typical properties include:

- **Areal density:** 1.02 kg/m^2 (0.21 lb/ft^2) at 3.2 mm thickness
- **CFD:** 76 kPa (11 psi) at 25%; 170 kPa (25 psi) at 50%
- **Compression set:** 5%
- **Thermal insulation, R-value:** 0.33 K.m^2/W (1.9 h.ft^2 °F/Btu.in)
- **Operating temperature range:** -50°C to 200°C (-58°F to 392°F)
- **Dielectric strength:** 3.4 kV/mm (85 V/mil)

Available in rolls or sheets for ease and safety of handling and assembly, the **Norseal** TRP Series offers standard thicknesses of 2.0 mm, 3.2 mm and 4.78 mm (0.078 inches, 0.125 inches and 0.188 inches).

Driving Further

In addition, a new product line currently in development picks up where the standard **Norseal** TRP Series leaves off. The **Norseal** TRP1000 Series is a modified silicone foam that combines a compression pad with a higher-level thermal runaway protection pad using a patent-pending, multilayered design.

Compared to the first-generation **Norseal** TRP line, TRP1000 offers greater durability to withstand a thermal event, along with higher resistance to

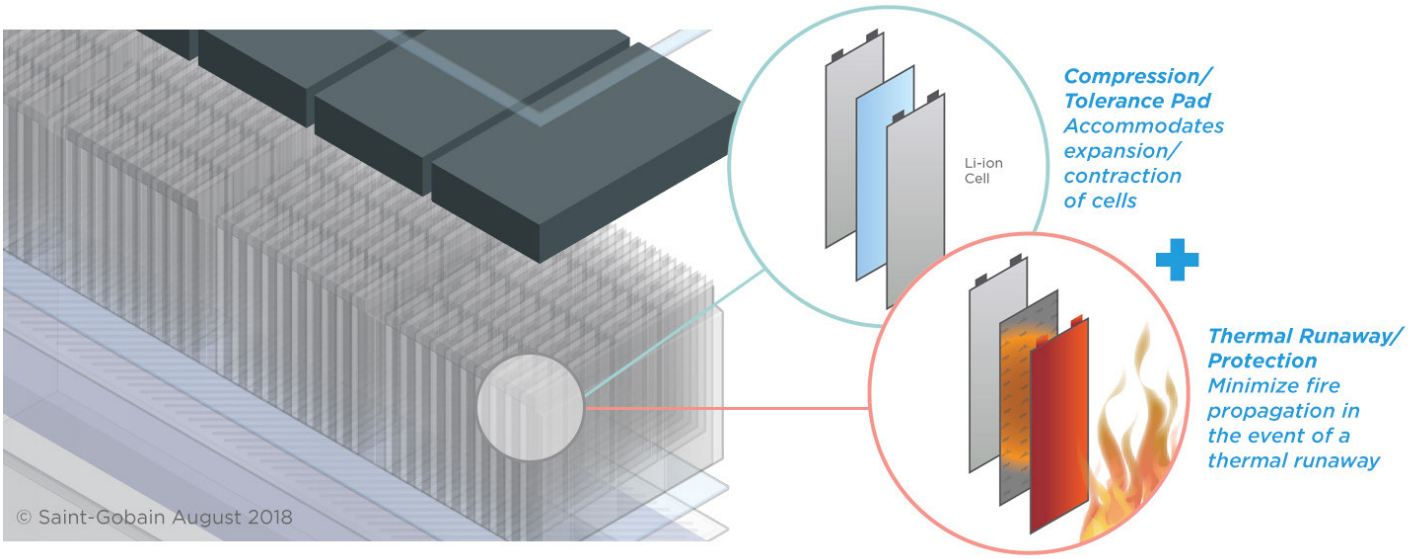

Figure 2. The **Norseal** TRP1000 series is a modified silicone foam that combines a compression/tolerance pad with a thermal runaway protection pad using a patent-pending, multilayered design.

Source: **Saint-Gobain**.

temperature and flame. Complete specs are yet to be finalized, but early evaluations have shown impressive results. These include:

- No self-ignition and measured temperature delta of more than 600°C (1112°F) with five minute exposure to 800°C (1472°F) hot plate
- Material integrity and insulation maintained; measured temperature delta of more than 600°C (1112°F) with six minute exposure to 1000°C (1832°F) direct torch

Configurations in development include thickness options of 1.6 mm (A/B construction) and 3.2 mm (A/B/A construction) (0.062 inches and 0.125 inches).

Our approach to battery protection is a comprehensive one. With both the **Norseal** TRP and TRP1000 Series, we have put forth a strategy that balances battery lifespan, performance and safety without compromise or trade-offs. Both our existing solutions and new materials in development are at the cutting edge of evolving EV technology, providing forward-looking solutions that pave the way for a future destined to include ever-increasing numbers of EVs on the world's roads.

Important Notice and Disclaimer: ***Norseal*** *TRP1000 is a developmental product that has not been commercialized for sale. The specifications are yet to be finalized. At this time, we cannot guarantee the availability, design, composition, performance properties, quality, specifications or pricing of the product, and all or some of them may be subject to change without notice when we actually commercialize the product. This is preliminary data and the data discussed herein only represents best estimates for the current product construction and its accuracy or completeness is not guaranteed. Such data should not be used for specification purposes.*

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